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HIGH-RESOLUTION SPECTROSCOPY AND DYNAMICS OF  
MULTIPHOTON PROCESSES IN ATOMS AND MOLECULES(U) ARGONNE  
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report summarizes research on resonantly enhanced multiphoton absorption, dissociation, and ionization processes in atoms and molecules. Multiphoton processes are studied using from one to three independently tunable visible and/or UV laser beams in order to establish both the underlying physics and the high degree of selectivity of multiphoton processes. Measurements are made to probe both the formation of excited molecular states and		

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20. ABSTRACT (Continued)

the subsequent behavior of excited states either in the presence or in the absence of further intense laser radiation. Detection methods include laser-induced fluorescence, ion mass analysis, and electron kinetic energy analysis. During the current reporting period, we have studied resonant multiphoton ionization processes in  $H_2^+$  and  $N_2^+$ , and have demonstrated that, in certain cases, it is possible to produce rotationally, vibrationally, and electronically state selected ions with greater than 95% purity. This is in accord with predictions based on the Franck-Condon approximation for excited state photoionization. In other cases, significant deviations from Franck-Condon behavior are observed, which provide greater insight into the general phenomena involved in excited state photoionization processes. In other experiments, we have studied resonantly enhanced multiphoton ionization of C atoms, including the determination of photoelectron angular distributions following excited state photoionization; two-color resonantly enhanced multiphoton ionization processes in  $N_2$  and CO; and three-color resonantly enhanced multiphoton ionization processes in  $N_2$ . Finally, three new instruments are currently under development that will provide significantly enhanced resolution, collection efficiency, and versatility in both the ion mass and the electron kinetic energy detection channels.

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**ANNUAL SUMMARY REPORT**

**HIGH-RESOLUTION SPECTROSCOPY AND DYNAMICS  
OF MULTIPHOTON PROCESSES IN ATOMS AND MOLECULES  
(Contract No. N00014-84-F-0017)**

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## I. SCIENTIFIC PROBLEM

This goal of this program is to study the high-resolution spectroscopy and the detailed mechanisms involved in sequences of resonant transitions induced in atoms and molecules by multicolor, multiphoton excitation. These studies are aimed at both determining the underlying physics and developing the high degree of selectivity of multicolor, multiphoton processes in atoms and molecules. This program involves the following three major activities.

First, in order to specify a sequence of resonant multiphoton transitions in a molecular target, it is necessary to have a precise knowledge of the rovibronic energy levels for each of the electronic states in the excitation sequence. For many molecules (including well-studied diatomic molecules such as  $N_2$  and  $O_2$ ), this information is fragmentary or lacking, especially for those electronic states that cannot be excited from the ground electronic state using single photon techniques. Thus, the first research area involves the study of the high resolution spectroscopy of excited electronic states, particularly electronic states that are dipole-forbidden in single photon absorption.

Second, it is necessary to establish the mechanisms and dynamical parameters governing multiphoton processes. For example, in order to design the most selective and sensitive excitation scheme, one must know the cross sections for each step, the decay mechanisms and the decay rates of the intermediate states, and the cross sections for all competing excitation processes, including nonresonant ones. Such information is largely unknown at this time.

Third, this work involves harnessing the rapid technological advances in lasers, optics, and electronics to produce a composite laser probe that can excite a preselected sequence of resonant steps within the five nanosecond duration of the laser pulse.

## II. SCIENTIFIC AND TECHNICAL APPROACH

The program uses a variety of laser sources, photon counting and charged particle detection equipment, and computer control equipment to address the problems described above. The major experimental components include the following. (1) A Nd:YAG oscillator/amplifier with 2nd, 3rd, and 4th harmonic

generation capability is used to pump several dye lasers, which together form the composite excitation source. (2) Three independently tunable dye lasers are presently in use and include a commercial dye laser with a frequency resolution of  $0.3 \text{ cm}^{-1}$  and two ANL-built dye lasers of the modified Littman design (two-grating grazing incidence). The latter dye lasers have a frequency resolution of  $0.025 \text{ cm}^{-1}$  at a fixed frequency and a resolution of approximately  $0.05 \text{ cm}^{-1}$  when frequency scanned. Nonlinear frequency upconversion capabilities exist for the commercial dye laser and for one of the modified Littman dye lasers, so that a composite three-color laser beam may include one visible and two UV beams. (3) A time-of-flight mass spectrometer is used to analyze the ions produced following multiphoton ionization. (4) A hemispherical electron energy analyzer is used to analyze the kinetic energy of the electrons produced following multiphoton ionization. (5) A fluorescence spectrometer is used to monitor fluorescence from laser excited states and from the decay of excited photofragments. ( ) A PDP 11/23 microprocessor and a PDP 11/03 microprocessor are used to scan the various lasers and to control the photon and charged particle detection channels. Both microprocessors are CAMAC interfaced to the laboratory hardware.

Summarizing, we are able to probe atoms and molecules with a fully flexible composite laser probe and to measure directly the photoions, photoelectrons, and fluorescent photons. Neutral fragments also can be monitored by subsequent ionization or by laser-induced fluorescence. Spectroscopic and dynamical information is then obtained by monitoring these detection channels as a function of the frequencies and polarization states of one or more of the components of the composite laser probe.

### III. PROGRESS

During the first two years of support by ONR, the program has produced several prototype resonantly enhanced multiphoton ionization (REMPI) studies of small molecules of fundamental interest. Among these were the first REMPI studies of the closed-shell diatomic molecules  $\text{H}_2$ ,  $\text{N}_2$ , and  $\text{CO}$  with photoelectron energy analysis. It has been our philosophy to focus attention on single color and multicolor, multiphoton processes in atoms and diatomic molecules (e.g.,  $\text{C}$ ,  $\text{Xe}$ ,  $\text{H}_2$ ,  $\text{N}_2$ ,  $\text{O}_2$ , and  $\text{CO}$ ). These molecules, particularly  $\text{H}_2$  and  $\text{N}_2$ , present a difficult experimental challenge owing to their large

ionization potentials; however, we felt that they were the best systems with which to begin establishing a basic understanding of REMPI processes in molecules, since they are the most amenable to theoretical interpretation.

During the most recent contract period, single and multicolor REMPI experiments have been performed on  $H_2$ ,  $N_2$ ,  $O_2$ ,  $Xe_2$  and atomic C using both mass spectrometry (MS) and photoelectron spectrometry (PES) to analyze the products of the ionization. Some of the highlights of these studies are described below.

In a REMPI/PES study of  $H_2$  via the intermediate  $C\ ^1\Pi_u$  resonant state, two issues were addressed. First, to what degree can vibrational state selected ions be prepared by photoionization of a Rydberg state. Second, what can be learned about the more subtle dynamical effects in excited state photoionization from a comparison of the observed vibrational branching ratios with accurate Franck-Condon factors. Photoelectron spectra were obtained at the wavelengths of the three photon Q(1) transitions of the  $C\ ^1\Pi_u$ ,  $v'=0-4 + X\ ^1\Sigma_g^+$ ,  $v''=0$  bands;  $H_2^+$  ions were formed in the  $X\ ^2\Sigma_g^+$ ,  $v^+$  levels. The most striking aspect of the photoelectron spectra is the dominance of the photoelectron peak corresponding to the  $v^+(X\ ^2\Sigma_g^+) = v'(C\ ^1\Pi_u)$  transition, indicating that the Rydberg electron is ionized while the vibrational state of the ionic core remains largely undisturbed. In addition, the weaker peaks with the greatest intensity are those adjacent to the  $v^+=v'$  peak. This agrees with expectations based on Franck-Condon factor calculations. However, while the qualitative agreement with the calculations is very good, the quantitative agreement is poor. For example, in the spectrum obtained via the  $C\ ^1\Pi_u$ ,  $v'=4$  level, the relative intensities of the  $v^+=3, 5$ , and  $6$  peaks are too large by factors of 3, 2, and 23, respectively, and the intensity of the  $v^+=4$  peak accounts for only 43% of the total, rather than the predicted 90%. The most likely causes of such deviations are: (1) a kinetic energy dependence of the electronic transition matrix element, which must be taken into consideration even within the Franck-Condon approximation; (2) an R-dependence of the same electronic transition matrix element, which, by definition, constitutes a breakdown of the Franck-Condon approximation; and (3) a  $v^+$ -dependence of the photoelectron angular distribution. The data represent a well defined case for further experimental and theoretical investigations of these excited state dynamics. We are planning to study both the angular distributions of the



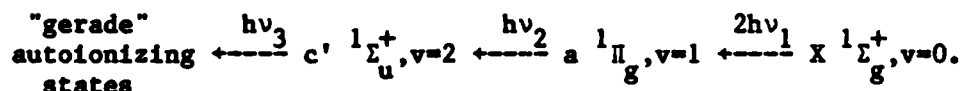
photoelectrons and the wavelength dependence of the vibrational branching ratios in order to determine which of the above effects is of major importance.

In another study, we sought a target molecule in which the first excited state of the ion could be accessed in the ionization step of the REMPI process, in order to study electronic as well as vibrational and rotational branching ratios. In addition, it was desirable that the neutral excited states of such a molecule show much greater configuration mixing than the excited states of  $H_2$ , since it is of interest to determine the effects of such interactions on the photoionization dynamics of excited states. We chose  $N_2$  for this study, since its neutral excited states have been very well characterized both experimentally and theoretically. Photoelectron spectra were obtained by single-color REMPI via the interacting  $b\ ^1\Pi_u$ ,  $c\ ^1\Pi_u$ , and  $o\ ^1\Pi_u$  states. These three interacting  $^1\Pi_u$  states have very different electron configurations. The  $c\ ^1\Pi_u$  state is a Rydberg state with the electron configuration  $\dots(1\pi_u)^4(3\sigma_g)^1\ 3p\pi_u$  that converges to the  $X\ ^2\Sigma_g^+$  ground state of the ion; the  $o\ ^1\Pi_u$  state is a Rydberg state with the electron configuration  $\dots(1\pi_u)^3(3\sigma_g)^2\ 3s\sigma_g$  that converges to the  $A\ ^2\Pi_u$  excited state of the ion; and the  $b\ ^1\Pi_u$  state is a combination of the electron configurations  $\dots(2\sigma_u)^2(1\pi_u)^3(3\sigma_g)^1(1\pi_g)^2$  and  $\dots(2\sigma_u)^1(1\pi_u)^4(3\sigma_g)^2(1\pi_g)^1$ , both of which differ from the  $X\ ^2\Sigma_g^+$  and  $A\ ^2\Pi_u$  states of  $N_2^+$  by two orbitals. Hence, it is possible to study photoionization from Rydberg states (including core-excited Rydberg states), valence states, and certain perturbed levels that are complex mixtures of these.

We found that the dominant ionization pathway for the multiphoton ionization of  $N_2$  via the  $o\ ^1\Pi_u\ v'=1, 2$  levels (which are relatively unperturbed) leads to the production of  $A\ ^2\Pi_u, v^+=1, 2$ , respectively. Hence, the ionizing transition strongly favors the removal of the outer  $3s\sigma_g$  electron, preserving both the electronic and vibrational levels of the ion core. This is the first experimental evidence in a molecular system showing the degree to which the electronic excitation of the ion core is retained following photoionization of a Rydberg state. Similar effects have been observed in the photoionization of the rare gas atoms (i.e., in all of the observed transitions, the spin-orbit state of the ion core was preserved), but have never been demonstrated for molecules.

We also investigated photoionization from various vibrational levels of the  $b\ ^1\Pi_u$  state, some of which strongly interact with the  $c\ ^1\Pi_u$ ,  $v=0$  level. In cases of strong interaction, the photoelectron spectra resembled that obtained by photoionization of the  $c\ ^1\Pi_u$ ,  $v=0$  level directly. Photoelectron spectra obtained by photoionization of vibrational levels of the  $b\ ^1\Pi_u$  state that are not perturbed by the  $c\ ^1\Pi_u$  state show a broad distribution of vibrational levels, in qualitative (although not quantitative) agreement with the corresponding Franck-Condon factors.

In addition to these single-color REMPI studies of  $H_2$  and  $N_2$ , we have performed a number of other single-color and multicolor experiments on  $N_2$ ,  $O_2$ , and  $CO$ , which are as yet unpublished. For example, we have observed single, double, and triple resonance REMPI processes in  $N_2$  via the long-lived  $a\ ^1\Pi_g$  state. The triple resonance experiments in  $N_2$  are pumped via the following excitation sequence



These experiments allow us to probe the gerade manifold of autoionizing Rydberg states. No information currently exists for these levels, since they are dipole-forbidden in single photon excitation from the  $X\ ^1\Sigma_g^+$  ground state. Therefore, these experiments will provide new data on excited states of  $N_2$  and on discrete-continuum interactions.

Finally, we have recently completed a study of the angular distributions of photoelectrons ejected following photoionization of the  $^1S_0$  and  $^3D_2$  excited states of atomic carbon. The carbon atoms were produced via laser photodissociation of  $CCl_4$ . This atom was chosen for study because of its importance as a prototype open-shell first row atom and because the experimental results are amenable to theoretical interpretation.

In addition to these experimental studies, we are also in the process of developing a new generation of mass and electron energy analyzers, which are designed specifically for use with pulsed lasers and which are optimized for collection efficiency, resolution, and versatility. Specifically, we are constructing three new instruments. The first is a "magnetic bottle" electron

spectrometer, which combines high resolution with very high collection efficiency. The second is a 10.2 cm mean radius hemispherical electron spectrometer, which will incorporate an optically-coupled area detector to enable the measurement of 1024 energy channels simultaneously. This is also a high resolution, high collection efficiency instrument; however, unlike the magnetic bottle, it will be capable of measuring photoelectron angular distributions in a straightforward, reliable manner. The third instrument under construction is a time-of-flight mass spectrometer designed for maximum versatility and ruggedness. The major improvement over the existing time-of-flight mass spectrometer is the separation of the ionization and detection regions into individually pumped vacuum chambers, thereby allowing the use of corrosive gases and/or high pressures in the ionization region. These instruments are expected to be operational in 1985 and the early part of 1986.

#### IV. PUBLICATIONS

The papers, abstracts of conference presentations, and invited talks prepared as part of this ONR program are listed on the following pages. New items during the current reporting period are papers 13-19, abstracts 12-16, and invited talks 17-31. In addition, papers 9-12 were submitted earlier, but were published during the last year.

## PAPERS

1. P. M. Dehmer, and J. L. Dehmer, "Observation of Bending Modes in the  $X^2\Pi_u$  State of the Acetylene Ion Using HeI Photoelectron Spectrometry," *J. Electron Spectrosc.* 28, 145 (1982).
2. E. D. Poliakoff, P. M. Dehmer, J. L. Dehmer, and R. Stockbauer, "Photoelectron-Photoion Coincidence Spectroscopy of Gas-Phase Clusters," *J. Chem. Phys.* 76, 5214 (1982).
3. P. M. Dehmer and S. T. Pratt, "Photoionization of ArKr, ArXe, and KrXe and Bond Dissociation Energies of the Rare Gas Dimer Ions," *J. Chem. Phys.* 77, 4804 (1982).
4. P. M. Dehmer, "Dissociation in Small Molecules," Desorption Induced by Electronic Transitions, Eds. N. H. Tolk, M. M. Traum, J. C. Tully, and T. E. Madey (Springer-Verlag, Berlin, 1982), p. 164.
5. P. M. Dehmer and S. T. Pratt, "VUV Spectroscopy of Rare Gas van der Waals Dimers," in Photophysics and Photochemistry in the Vacuum Ultraviolet, edited by S. McGlynn, G. Findley, and R. Huebner (D. Reidel Publ., Dordrecht, Holland, 1984), in press.
6. S. T. Pratt, E. D. Poliakoff, P. M. Dehmer, and J. L. Dehmer, "Photoelectron Studies of Resonant Multiphoton Ionization of CO via the  $A^1\Pi$  State," *J. Chem. Phys.* 78, 65 (1983).
7. E. D. Poliakoff, J. L. Dehmer, P. M. Dehmer, and A. C. Parr, "Vibrationally-Resolved Photoelectron Angular Distributions for  $H_2$ ," *Chem. Phys. Lett.* 96, 52 (1983).
8. S. T. Pratt, P. M. Dehmer, and J. L. Dehmer, "Resonant Multiphoton Ionization of  $H_2$  via the  $B^1\Sigma_u^+$ ,  $v=7$ ,  $J=2$  and 4 Levels with Photoelectron Energy Analysis," *J. Chem. Phys.* 78, 4315 (1983).
9. S. T. Pratt and P. M. Dehmer, "On the Dissociation Energy of  $ArCO_2^+$ ," *J. Chem. Phys.* 78, 6336 (1983).
10. P. M. Dehmer, "Rydberg States of van der Waals Molecules — A Comparison with Rydberg States of Atoms and of Chemically-Bonded Species," *Comments At. Mol. Phys.* 13, 205 (1983).
11. P. M. Dehmer and W. A. Chupka, "Photoabsorption and Photoionization of HD," *J. Chem. Phys.* 79, 1569 (1983).
12. S. T. Pratt, P. M. Dehmer, and J. L. Dehmer, "Two Photon Resonant, Four Photon Ionization of CO via the  $A^1\Pi$  State with Photoelectron Energy Analysis," *J. Chem. Phys.* 79, 3234 (1983).
13. J. L. Dehmer, P. M. Dehmer, and S. T. Pratt, "Multiphoton Ionization as a Probe of Molecular Photoionization Dynamics," in Electron-Molecule Collisions and Photoionization Processes, eds. V. McKoy, H. Suzuki, K. Takayanagi, and S. Trajmar (Verlag Chemie International Inc., 1983) p. 21.

Papers - Continued

14. P. M. Dehmer, P. J. Miller, and W. A. Chupka, "Photoionization of  $N_2 X^1\Sigma^+$ ,  $v''=0$  and 1 Near Threshold -- Preionization of the Worley-Jenkins<sup>8</sup> Rydberg Series," J. Chem. Phys. 80, 1030 (1984).
15. S. T. Pratt, P. M. Dehmer, and J. L. Dehmer, "Photoionization of Excited Molecular States.  $H_2 C^1\Pi_u$ ," Chem. Phys. Lett. 105, 28 (1984).
16. S. T. Pratt, P. M. Dehmer, and J. L. Dehmer, "State Selection by Resonant Multiphoton Ionization:  $N_2 A^2\Pi_u, v^+$ ," J. Chem. Phys. 80, 1706 (1984).
17. S. T. Pratt, P. M. Dehmer, and J. L. Dehmer, "Photoelectron Studies of Resonant Multiphoton Ionization of Molecular Nitrogen," J. Chem. Phys. (in press).
18. P. M. Dehmer, "Photoionization of the OH Radical," Chem. Phys. Lett. (submitted).
19. P. M. Dehmer, S. T. Pratt, and J. L. Dehmer, "Photoionization of Excited Molecular States Using Multiphoton Excitation Techniques," in Laser Techniques in Extreme Ultraviolet (American Institute of Physics, New York, 1984), in press.

# ABSTRACTS OF CONFERENCE PRESENTATIONS

1. J. L. Dehmer, E. D. Poliakoff, and P. M. Dehmer, "Photoelectron Angular Distributions From Multiphoton Ionization. Seven Photon Ionization of Kr at 532 nm," XIII DEAP Meeting, 3-5 December 1981, New York, New York, Bull. Am. Phys. Soc. 26, 1322 (1981).
2. E. D. Poliakoff, P. M. Dehmer, J. L. Dehmer, and R. Stockbauer, "Photoelectron-Photoion Coincidence Spectroscopy of Gas-Phase Clusters," XIII DEAP Meeting, 3-5 December 1981, New York, New York, Bull. Am. Phys. Soc. 26, 1322 (1981).
3. P. M. Dehmer and S. T. Pratt, "Systematics of Electronic Structure in Rare Gas van der Waals Molecules," (invited talk), NATO Advanced Study Institute on Photophysics and Photochemistry in the Vacuum Ultraviolet, 15-28 August 1982, Lake Geneva, Wisconsin, Book of Abstracts.
4. S. T. Pratt, E. D. Poliakoff, P. M. Dehmer, and J. L. Dehmer, "Photoelectron Studies of Resonant and Nonresonant Multiphoton Ionization Processes," Gordon Conference on UV/Visible Multiphoton Ionization and Dissociation Processes, 12-16 July 1982 (no abstract available).
5. P. M. Dehmer, "VUV Spectroscopy of Rare Gas van der Waals Dimers," (invited talk), Proceedings of the 2nd European Workshop on Molecular Spectroscopy and Photon-Induced Dynamics, September 27-30, 1982, Flevopolder, The Netherlands, AMOLF-Report #83-3, p. 11.
6. J. L. Dehmer, P. M. Dehmer, and S. T. Pratt, "Multiphoton Ionization as a Probe of Molecular Photoionization Dynamics," (invited talk), Proceedings of the U.S./Japan Seminar on Electron-Molecule Collisions and Photoionization Processes, 26-29 October 1982, Pasadena, California, p. 18.
7. S. T. Pratt, P. M. Dehmer, and J. L. Dehmer, "Resonant Multiphoton Ionization of  $H_2$  via the  $B^1\Sigma_u^+$  State with Photoelectron Energy Analysis," XIV DEAP Meeting, 23-25 May 1983, Boulder, Colorado, Bull. Am. Phys. Soc. 28, 808 (1983).
8. P. M. Dehmer, S. T. Pratt, E. D. Poliakoff, and J. L. Dehmer, "Photoelectron Studies of Resonant Multiphoton Ionization of CO via the  $A^1\Pi$  State," XIV DEAP Meeting, 23-25 May 1983, Boulder, Colorado, Bull. Am. Phys. Soc. 28, 792 (1983).
9. P. M. Dehmer, "Decay of Rydberg States via Autoionization and Predissociation," (invited talk), XIV DEAP Meeting, 23-25 May 1983, Boulder, Colorado, Bull. Am. Phys. Soc. 28, 779 (1983).
10. S. T. Pratt, E. D. Poliakoff, P. M. Dehmer, and J. L. Dehmer, "Photoelectron Studies of Resonant Multiphoton Ionization of CO via the  $A^1\Pi$  State," Proceedings of the XIII International Conference on the Physics of Electronic and Atomic Collisions, July 27 - August 2, 1983, Berlin, Germany, p. 69.

ABSTRACTS OF CONFERENCE PRESENTATIONS - Continued

11. S. T. Pratt, P. M. Dehmer, and J. L. Dehmer, "Resonant Multiphoton Ionization of  $H_2$  via the  $B^1\Sigma_u^+$ ,  $v = 7$ ,  $J = 2$  and 4 Levels with Photoelectron Energy Analysis," Proceedings of the XIII International Conference on the Physics of Electronic and Atomic Collisions, 27 July - 2 August 1983, Berlin, Germany, p. 70.
12. P. M. Dehmer, S. T. Pratt, and J. L. Dehmer, "Photoionization of Excited Molecular States using Multiphoton Excitation Techniques," (invited talk), Proceedings of the Second Topical Meeting on Laser Techniques in the Extreme Ultraviolet, Boulder, Colorado, 5-7 March 1984, p. MB6-1.
13. J. L. Dehmer, P. M. Dehmer, and S. T. Pratt, "Photoelectron Studies of Excited Molecular States.  $H_2 C^1\Pi_u$  and  $N_2 O_3^1\Pi_u$ ," XIII International Conference on Quantum Electronics, Anaheim, California, 18-21 June 1984, Book of Abstracts.
14. P. M. Dehmer, P. J. Miller, and W. A. Chupka, "Photoionization of Vibrationally Excited  $N_2$ ," XV DEAP Meeting, 30 May - 1 June 1984, Storrs, Connecticut, Bull. Am. Phys. Soc. 29, 798 (1984).
15. P. M. Dehmer, "Photoionization of the Hydroxyl Radical," XV DEAP Meeting, 30 May - 1 June 1984, Storrs, Connecticut, Bull. Am. Phys. Soc. 29 799 (1984).
16. S. T. Pratt, P. M. Dehmer, and J. L. Dehmer, "Photoelectron Studies of Resonant Multiphoton Ionization of  $H_2$  and  $N_2$ ," XV DEAP Meeting, 30 May - 1 June 1984, Storrs, Connecticut, Bull. Am. Phys. Soc. 29, 800 (1984).

INVITED TALKS, COLLOQUIA, AND SEMINARS

1. P. M. Dehmer, "Systematics of Electronic Structure within Families of van der Waals Molecules as Revealed by VUV Spectroscopy," Interdisciplinary Physical Sciences Seminar, Yale University, 30 November 1981.
2. P. M. Dehmer, "Systematics of Electronic Structure in Rare Gas van der Waals Molecules," Chemistry Department Seminar, Brookhaven National Laboratory, 19 January 1982.
3. P. M. Dehmer, "Systematics of Electronic Structure Within Families of van der Waals Molecules as Revealed by VUV Spectroscopy," Atomic and Molecular Sciences Seminar, Argonne National Laboratory, 18 February 1982.
4. P. M. Dehmer, "Systematics of Electronic Structure Within Families of van der Waals Molecules," Chemistry Department Colloquium, Illinois Institute of Technology, 12 March 1982.
5. P. M. Dehmer, "Systematics of Electronic Structure Within Families of van der Waals Molecules," Optical Physics - Chemical Physics Seminar, University of Maryland, 20 April 1982.
6. P. M. Dehmer, "Dissociation in Small Molecules," Discussion Leader, First International Workshop on Desorption Induced by Electronic Transitions (DIET-I), Williamsburg, Virginia, 12-14 May 1982.
7. P. M. Dehmer, "Systematics of Electronic Structures Within Families of van der Waals Molecules," Chemistry Department Seminar, University of Illinois at Chicago Circle, 18 May 1982.
8. J. L. Dehmer, "Molecular Photoionization Dynamics - Progress and Prospects," Physics Colloquium, University of Chicago, 27 May 1982.
9. P. M. Dehmer, "Molecular Spectroscopy - Where are the New Frontiers?", Programmatic Division Directors' Talk, Argonne National Laboratory, 7 June 1982.
10. J. L. Dehmer, "Overview of Experimental and Theoretical Studies of Resonance Processes in Molecular Photoionization by Single-Photon and Multiphoton Excitation," Gordon Research Conference on Electron Spectroscopy, Wolfeboro, New Hampshire, 19 July 1982.
11. P. M. Dehmer, "VUV Spectroscopy of Rare Gas van der Waals Dimers," NATO Advanced Study Institute on Photophysics and Photochemistry in the Vacuum Ultraviolet, Lake Geneva, Wisconsin, 19 August 1982.
12. P. M. Dehmer, "VUV Spectroscopy of van der Waals Dimers and Heavier Clusters," 2nd European Workshop on Molecular Spectroscopy and Photon-Induced Dynamics, Flevopolder, The Netherlands, 27 September 1982.
13. J. L. Dehmer, "Multiphoton Ionization as a Probe of Molecular Photoionization Dynamics," U.S./Japan Seminar on Electron-Molecule Collisions and Photoionization Processes, Pasadena, California, 26 October 1982.



INVITED TALKS, COLLOQUIA, AND SEMINARS - Continued

14. J. L. Dehmer, "Resonant Processes in Molecular Photoionization," Meeting of the American Physical Society, Los Angeles, California, 24 March 1983.
15. P. M. Dehmer, "Photoelectron Spectroscopy Following Resonantly Enhanced Multiphoton Ionization," Workshop on Experiments, Argonne National Laboratory, 16 April 1983.
16. P. M. Dehmer, "Decay of Rydberg States via Autoionization and Predissociation," Fourteenth Meeting of the Division of Electronic and Atomic Physics, Boulder, Colorado, 23 May 1983.
17. J. L. Dehmer, "Resonant Processes in Molecular Photoionization," Gordon Research Conference on Atomic Physics, New London, New Hampshire, 8 July 1983.
18. J. L. Dehmer, "Resonant Multiphoton Ionization as a Coincidence-Equivalent Means for Studying Photoionization of Excited Molecular States," International Workshop on Atomic and Molecular Photoionization, Berlin, West Germany, 25 July 1983.
19. P. M. Dehmer, "Photoionization of Clusters," International Workshop on Atomic and Molecular Photoionization, Fritz-Haber-Institut der Max-Planck Gesellschaft, Berlin, West Germany, 26 July 1983.
20. S. T. Pratt, "Multiphoton Ionization as a Probe of Excited State Photoionization Dynamics," Atomic and Molecular Science Seminar, Argonne National Laboratory, 10 October 1983.
21. S. T. Pratt, "Photoionization Dynamics from Excited Molecular States," Chemical Physics Seminar, The Aerospace Corporation, Los Angeles, California, 24 October 1983.
22. S. T. Pratt, "Multiphoton Ionization as a Probe of Excited State Photoionization Dynamics," Interdisciplinary Science Seminar, Yale University, 28 November 1983.
23. S. T. Pratt, "Multiphoton Ionization as a Probe of Excited State Photoionization Dynamics," Chemistry Department Seminar, Virginia Commonwealth University, 29 November 1983.
24. S. T. Pratt, "Multiphoton Ionization as a Probe of Excited State Photoionization Dynamics," Chemistry Department Seminar, University of Nevada, 13 January 1984.
25. J. L. Dehmer, "Photoionization Dynamics of Selectively Excited Molecular States," Chemical Physics Seminar, California Institute of Technology, 14 February 1984.
26. J. L. Dehmer, "Photoionization Dynamics of Selectively Excited Molecular States," Chemical Physics Seminar, University of Southern California, 16 February 1984.

INVITED TALKS, COLLOQUIA, AND SEMINARS - Continued

27. P. M. Dehmer, "Photoionization of Excited Molecular States Using Multiphoton Excitation Techniques," Second Topical Meeting on Laser Techniques in the Extreme Ultraviolet, Boulder, Colorado, 5-7 March 1984.
28. P. M. Dehmer, "Multiphoton Ionization as a Probe of Electronic Structure of Small Molecules," Gordon Research Conference on Visible/UV Multiphoton Ionization and Dissociation, Colby-Sawyer College, New London, New Hampshire, 15 June 1984.
29. S. T. Pratt, "Survey of Recent Multiphoton Ionization Studies Using Electron Spectroscopy," Gordon Research Conference on Electron Spectroscopy, Wolfeboro, New Hampshire, 16 July 1984.
30. P. M. Dehmer, "Photoelectron Studies of Excited Molecular States," Third International Conference on Multiphoton Processes, Crete, Greece, 5-11 September 1984.
31. P. M. Dehmer, "Photoionization Studies of Ground and Excited States of Molecules — Progress and Prospects," Chemical Physics Seminar, University of Indiana, 25 October 1984.

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